BULLETIN

ENGINEERING DEPARTMENT

NATIONAL LAMP WORKS

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Bulletin 34

Country Home Lighting

NATIONAL QUALITY

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CO-OPERATION PROGRESS QUALITY

PREFACE

This bulletin has been prepared from information gathered by Evan J. Edwards, Electrical Engineer of the National Lamp Works. The aim has been to avoid technical phraseology and lengthy discussion of the more involved principles of illuminating engineering. Those readers who are interested in lighting in its broader aspects, are referred to the bulletins listed on page 19 of this bulletin. Bulletin 7C, "Fundamentals of Illumination Design," explains and illustrates the basic principles of illumination practice and a prior reading of this bulletin will give a clearer conception of illumination problems as discussed in the other bulletins.

Country Home Lighting

AN electric country home lighting system is, in its essentials, closely comparable with the electric system employed on the modern gasoline-driven automobile. In either are to be found an engine, a generator, a storage battery, switching devices, wiring, and incandescent lamps with their equipment. In the latter, however, the necessity for economizing on space and weight—and at the same time providing a ruggedness capable of withstanding extremely severe service conditions, and a means for automatically regulating the current generated at speeds ranging from zero to 40 or 50 miles an hour—introduces complications which need not and do not exist in country home lighting plants. The interest which has recently been shown in electric home lighting by means of small isolated plants is due no doubt in some measure to the success of similar but more complicated electric systems on automobiles.

The Plant

The majority of country home lighting outfits are supplied complete with gasoline, kerosene, or gas engine; generator; storage battery; and switchboard. The engine is usually an improved form of the type at present in extended use for driving pumps, operating washing machines, running churns, etc. Its operation is simple; it is rarely necessary to do more than supply fuel and oil as required. The speed of the engine is usually controlled by means of a simple governor which either reduces the supply of fuel reaching the cylinder of the engine or causes the engine to miss explosions when the speed exceeds a certain value. The generator is, of course, nothing more than a direct-current electric machine, which when driven at a constant speed by the engine, will supply electrical energy at a nearly constant voltage. The storage battery, as its name implies, may be considered as a reservoir for the storage of electricity supplied by the generator. When the engine is running, lamps, small motors, or other appliances receive their current direct from the generator and if more energy is generated than is required by the appliances, the surplus is stored in the battery for future use. When the engine is not running, the energy which

has been stored in the battery is available, and there is no interruption of service. The switchboard usually carries an ammeter, which indicates the current flowing to or from the battery; a voltmeter, which shows at what electrical pressure current is being distributed to the various appliances; such switches and controlling devices as are necessary to the proper operation of the plant; and sometimes an ampere-hour meter which gives some indication of the amount of energy stored in the battery for future needs.

Those who drive electrically equipped automobiles know that storage batteries often withstand abuse and neglect that could hardly exist in a stationary plant, yet a glance at an instruction book on the care of a battery is likely to create the impression that a storage cell is an exceedingly delicate piece of apparatus. A study of the instructions will reveal, however, that the rules for the proper care of any type of battery are simple and may be easily observed. Briefly, the points which must be borne in mind are: the battery should not be undercharged or overcharged to an excessive degree, or charged at too high a rate; it should not be over-discharged, or discharged at too high a rate; a discharged lead battery should not be allowed to stand idle for long periods; the liquids in the cells must be kept at the proper height and only *pure* water used to replace that evaporated; the sediment which gradually forms within lead cells should not be allowed to reach the plates. The instructions of the manufacturer explain in detail the methods of testing cells to insure proper operating conditions at all times.

The name "Country Home Lighting Outfit" is descriptive of but a small part of the vast field to which these small isolated electric plants are adapted. They are used in country and suburban homes, on farms and ranches, in small towns not served by an electric utility company, and even in theaters where electrical energy is not available for producing lighting effects or for projecting motion pictures. They are taken to homes in the Rocky Mountains, to ranches in the hot, dry territory of the Middle Southwest, and are used aboard boats plying along the coast and on the Great Lakes. In size, these outfits range from about 500 watts upwards. For the usual country or suburban home consisting of seven or eight rooms with bathroom, attic, and basement, a plant with a generator capacity of 750 watts will provide ample energy for lighting the house and outbuildings, and will permit the use of an electric iron, small

motors, or a toaster during the daytime when the lighting system is not in use or when not more than a few lights are used. Although a plant of smaller capacity would, under usual conditions, provide capacity sufficient for lighting alone, a size at least no smaller than 750 watts should be selected, because, with a smaller plant, electric irons and similar devices cannot be used to the best advantage. In general, the capacity of the plant should be equal to the total wattage of the lamps which are likely to be in use at any one time, provided the required capacity, as calculated in this way, exceeds 750 watts.

Wiring

The problem of wiring the home for service from a small isolated plant is different from that of wiring one for service from a central station circuit only in the respect that, in the former case, lamps and appliances require a high current at a low voltage, whereas in the latter they require high voltage and low current. While a house wired for 110-volt service may need some changes in wiring before the country home lighting outfit is connected to the wires, an installation made for 28-32 volt operation and insulated to the 110-120 volt standard specification, will be ready for connection to any line which may come through the country in the future. Only the lamps and the electrical appliances themselves need be changed. The converse would not in general be true for the reason that the lower voltage could not force sufficient current through the system to cause the connected apparatus to operate efficiently, and furthermore the energy taken, in forcing current through, is lost. Country home lighting plants usually generate energy at 28-32 volts pressure and a lamp, flat iron, or other device designed to operate at 28-32 volts requires four times the current that apparatus taking the same power but designed to operate on 120 volts pressure requires. If a country home were wired for 110-volt service and later for some reason a 28-32 volt isolated plant were installed and connected, and 28-32 volt lamps and appliances used, the inadequacy of the wiring would be most apparent in those circuits where electric irons, toasters, or other heating appliances high in wattage were connected, for the wires through which such appliances were supplied could not furnish them with the heavy current which they require, with the result that they would be

slow to heat and might possibly never get hot enough for use. In the same way, the circuits supplying current to incandescent lamps would be forced to carry a heavier current than they were designed to carry, but if the circuits were short and the power required by the lamps were small, the lamps would operate satisfactorily. However, if several lamps were connected to a single circuit of considerable length, the decrease in their brilliancy might be very marked. No. 14 wire, which is the size commonly used for 110-volt lighting circuit wiring, is satisfactory for a considerable part of a 28-32 volt installation but special circuits should be provided for all devices consuming over 300 watts, for circuits which must carry the total current for small individual loads aggregating over 300 watts, and even for small loads at a great distance from the plant.

The accompanying chart, Fig. 1, of proper wire sizes is given for various loads, in watts, and lengths of copper wire, in feet, for a voltage drop within desirable limits. It is worth noting at this point that in all the scales of wire sizes the larger wire has the smaller number; thus, No. 12 wire is larger than No. 14. Wire sizes appearing on the chart are the Brown & Sharpe (B & S) wire gauge, the one in common use.

To use the chart, the actual length of wire which is needed, in feet, and the maximum load, in watts, must be known. The wire length includes both wires between the two points connected for each circuit. For example, 225 feet of wire is needed to connect a load of 280 watts to a supply approximately 110 feet distant. By following an imaginary 280-watt line horizontally across until the vertical line corresponding to 225 feet is reached, as indicated on the table by the fine arrows, the point of intersection is found to lie in the area representing a wire size of No. 8 and this size wire may be used.

The chart may be used to find the wire size for larger wattages or greater lengths of wire than those given directly on the chart. The method is simple: the number of watts is multiplied by the number of feet, giving a product which, for the sake of convenience, may be termed "watts-feet"; now two numbers are found on the chart which when multiplied together will equal the "watts-feet"; the wire size is then found by reading the intersection of the imaginary lines corresponding to the two numbers on the chart. For example, it is desired to find the wire size for a load of 1750 watts at a distance of 20 feet, which requires at least 40 feet of wire. The

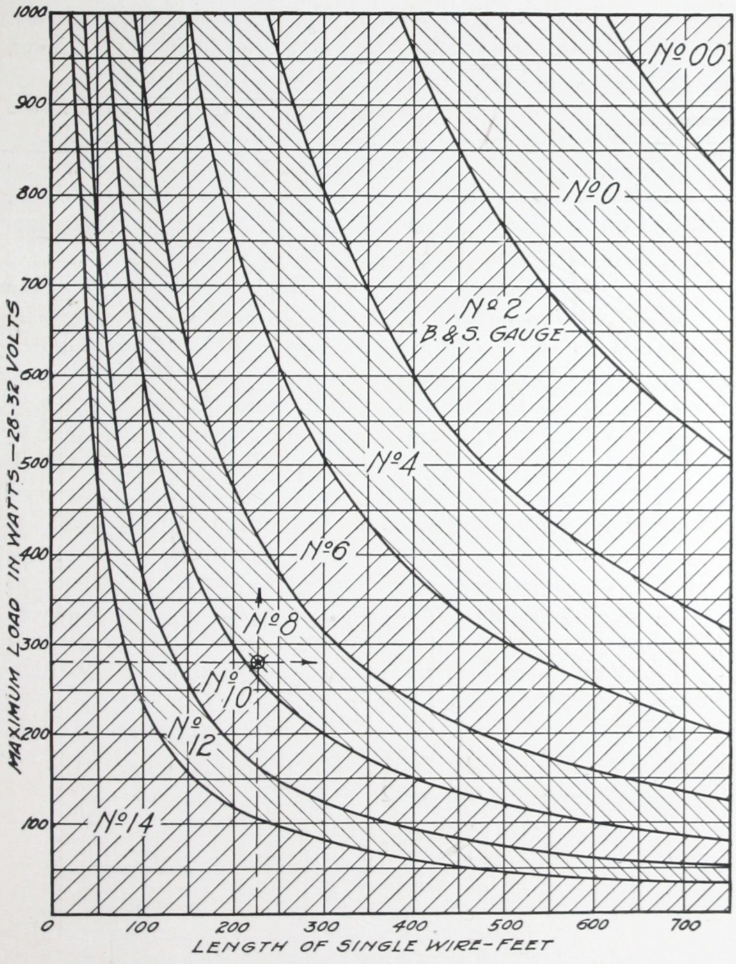

Fig. 1—Chart For Obtaining Copper Wire Size (B & S Gauge) for 28-32 Volt Circuits. Wire Length To Be Used is *Twice* The Wiring Distance Between Points

"watts-feet" value equals 1750 x 40, or 70,000. There are several combinations of numbers whose product equals the "watts-feet"; 200 watts—350 feet, 350 watts—200 feet, 700 watts—100 feet,

500 watts—140 feet. By reference to the chart it is found that No. 8 wire fulfills the requirements for any one of these conditions, and this size should be used for a 1750 watt load carried 20 feet.

The illumination should be carefully planned before the house is wired, for at that time it is easy to provide for future comfort with correctly placed outlets for lights and control devices. The location of base-board outlets for portable lamps and for toasters, irons, and other appliances should be given consideration. Those who have experienced the convenience of electric service know that there is nearly always a desire to use more appliances, and the anticipation of future wants at the time the wiring is being done will result in a cheaper and better installation. As was noted before, special wiring is required for those outlets which are to furnish current for appliances using more than 300 watts.

Convenience of operation is an important feature of the lighting equipment. For any circuit there is usually one place for the switch which is more convenient than any other. For instance, for controlling the lamps suspended from the center of the ceiling of a room, a switch should be placed near the door of the room and on the side of the doorway nearest the door handle. The hall lights on one floor should be controlled from the floor above or below them as well as from the floor on which they are installed. Controlling devices may be placed in the bases of portable lamps, where they are most accessible. Wall switches are usually placed four feet above the floor. These few instances are mentioned only to point out that thought given to planning a system will be repaid by future satisfaction.

The Lighting of the House

Good lighting results from a combination of good taste and the common-sense application of well-known principles. There are usually several excellent solutions to each lighting problem, the choice depending almost entirely upon individual tastes. A consideration of the requirements of good lighting will be helpful in planning a desirable installation.

Artificial light is used to assist the eye in perceiving and distinguishing objects at night. The eye is a very delicate organ and every precaution should be taken to treat it properly. Conditions producing unusual adaptations of any part of the eye will cause strain and, eventually, injury. Such conditions arise from bright

Fig. 2—Two 40-Watt Lamps Illuminate This Dining Room
This Installation Has Been in Use Since June, 1911

light sources, sharp contrasts, or rapidly changing intensities in the field of vision. Reflectors and shades are used to protect and assist the eye by minimizing these conditions.

When a ray of sunlight passes through a prism it is broken up into its constituent parts and is found to be composed of all gradations of color from violet to red. Artificial light is also composed of different colors but usually in proportions differing from those in sunlight; some illuminants are even lacking in a number of the colors. An object appears red, or yellow, or blue, simply because it reflects the red, or the yellow, or the blue rays, respectively, and

absorbs most of the others that happen to strike it. It is obvious that a red object can not appear red unless red rays are present. Thus it can be seen that the color of an object, under most artificial illuminants, will appear different from what it will in daylight. A further conclusion is that the color quality of the light used influences the appearance of the decorations and everything within the home.

A room with a predominant yellow or red tone gives a warm, cheerful impression, while a feeling of cold formality is experienced by many in a room furnished in blue. It is, therefore, only natural that home decorating should tend toward yellow and red color schemes and it is evident that the light used should, in general, contain more yellow and red than blue in order to enrich the effect. Nearly all illuminants of the present day do not contain as much blue as daylight, although they are nearer white than the earlier lamps. So the important problem of color is automatically well cared for in the lighting of the home.

In laying out the illumination for the home, the aim should be to provide a high intensity of light where needed; shadows should not be eliminated for they are essential to perspective and relief; and last and most important glare should be avoided so far as possible.

In order to provide sufficient intensity it is not necessary that the largest lamp possible should be used; a lamp large enough to give the amount of illumination necessary for the desired effect is all that is required. The small lamp has a place in the home as has the large lamp, but the medium sized lamp will be found to be best adapted for general lighting. For close work, such as reading, writing, or sewing, a high intensity of illumination is necessary if eye strain and discomfort are to be avoided. It is a simple matter, of course, to determine by a trial of several lamps which size best suits the requirements from the standpoint of intensity.

It is much more easy to distinguish objects in true proportion where soft shadows are present and so the shadows should not be destroyed by using too many sources which give light from many angles. A moderate amount of light, directed so that a minimum will be reflected from table tops and the glass coverings of pictures, will be found the most satisfactory. Shade and softened shadows are essential to the proper appearance of rooms in the home.

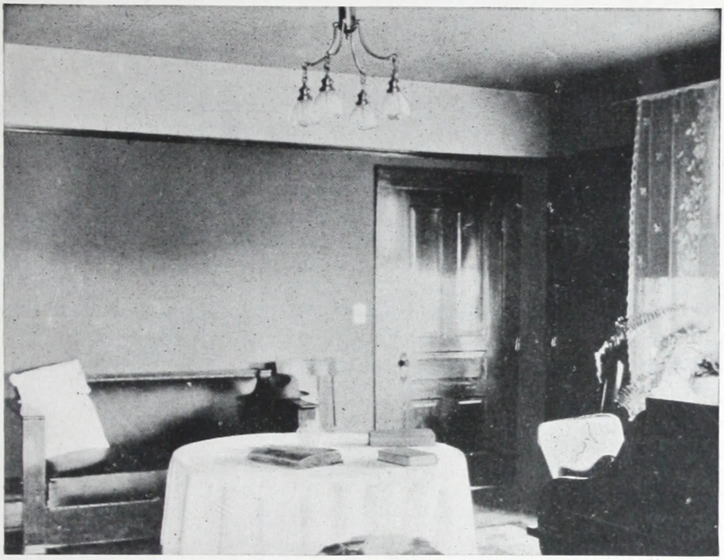

Fig. 3—This Living Room is Lighted by Four 20-Watt Lamps
The Installation Was Made in 1912

Improvements in incandescent lamps have resulted in intensely bright light sources which are being used to an increasingly greater extent. These brilliant sources make the problem of glare more important. Glare is easily taken care of in the home, however, if the principle of the proper diffusion of light is understood.

Glare is due in many cases to the high contrast existing between a bright light source in the field of vision and its background. The discomfort resulting from the glare of a low-hanging chandelier is similar to that experienced when facing bright automobile headlamps against a dark background, except that it is milder and may not be recognized as harmful. The remedy is to remove or minimize the contrasts so far as possible. It is especially important that glare should not be present in the home, because here the eyes of children, which are particularly sensitive to abuse, may be permanently injured. Special attention should be given the lighting of those rooms in which people sit for some time, for here the contrasts remain in a comparatively fixed position with respect to the eye and glare may do the greatest harm under this condition. Even in a room in which

the occupants move about most of the time, such as the kitchen, it is advisable to avoid extreme contrasts.

Making the source appear larger will reduce the glare and it is for this reason that diffusing reflectors or globes should be used with high brilliancy light sources. The frosted globe, the inner surface of which is either etched with acid or sand-blasted, and the opal-white globe, are examples of diffusing glassware. Such units decrease the brightness by apparently increasing the size of the light source; that is, putting a diffusing ball over a lamp results in less light shining out from each square inch of the luminous surface of the ball. However, there are a great many more square inches and the total amount of light is the same except for the portion absorbed in passing through the diffusing globe.

Since incandescent lamps are necessarily so constructed that the greater portion of their light comes off in horizontal directions, the reflecting equipment, in addition to diffusing the light, should be designed to control the light by redirecting the rays into useful directions. There are three general classes of reflectors—direct, semi-indirect, and indirect—and each class has certain distinguishing characteristics.

The direct-lighting reflector throws most of the light downward by means of glass or metal reflecting surfaces. The majority of fixtures formerly in use were in this class. In the average home, this general class is still used in nearly all rooms. Direct-lighting reflectors distribute the illumination well but often may give glare and disagreeable shadows. It is usually advisable to employ bowl-frosted lamps for direct-lighting fixtures.

Semi-indirect units send most of the light upward to be reflected back by the ceiling and upper walls, but allow a part of the light to pass downward through the unit. The most common units of this class consist of translucent glass or alabaster bowls containing one or more lamps. These units are very popular for the general lighting of the most used rooms because they offer good diffusion, minimize glare and are exceedingly attractive in appearance.

The indirect fixture is equipped with an opaque reflector which directs all of the light upward. Because of their good diffusion and minimization of glare, indirect units are excellent for general lighting of large rooms but they require a greater proportion of lamps and

should be supplemented with other units for localized lighting where a high intensity of illumination is desired.

The efficiency of light distribution should be taken care of in the selection of the reflector and when a semi-indirect or indirect system is used the color of the upper walls and ceiling should be white or some light tint.

Decorative floor and table lamps are being used more and more extensively and the many patterns which are on the market indicate that practically all of them have been designed from a decorative standpoint, with shades of glass, silk, or a combination of the two. They are of value for the decorative effect, but unless very carefully designed, furnish little or no control of the light from the incandescent lamp. The shades must be dense, because the unit is always in the field of vision, and nearly all the light that comes from the lamp is in a downward direction. With a table lamp, this usually makes the intensity of illumination on the table top too high for comfort if the rest of the room is to receive light from the same source. A table or floor lamp can be designed, as shown in Fig. 4, to be effective by directing downward only enough illumination to give a low intensity on the table top, by lighting the shade sufficiently to bring out the pattern, and by directing the remainder of the light given off by the incandescent lamp to the ceiling where it is reflected about the room without discomforting brightness. There are floor lamps on the market which fill these requirements by a combination of direct and indirect lighting. The direct light is thrown downward and the lamps are shut out of the direct line of vision by a silk, cretonne, or glass shade; the indirect light for the general illumination of the room is furnished by lamps in an indirect reflector at the top of the floor lamp. Either the direct or indirect part of the lamp may be used and the whole effect is very pleasing.

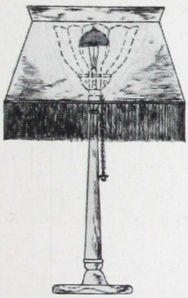

Fig. 4—Decorative Table Lamp Designed to Utilize the Light Efficiently

It is worth noting in connection with portable lamps that in a house already built it is much less expensive as a rule to install a base-board outlet than a ceiling outlet, particularly for a room on the first floor.

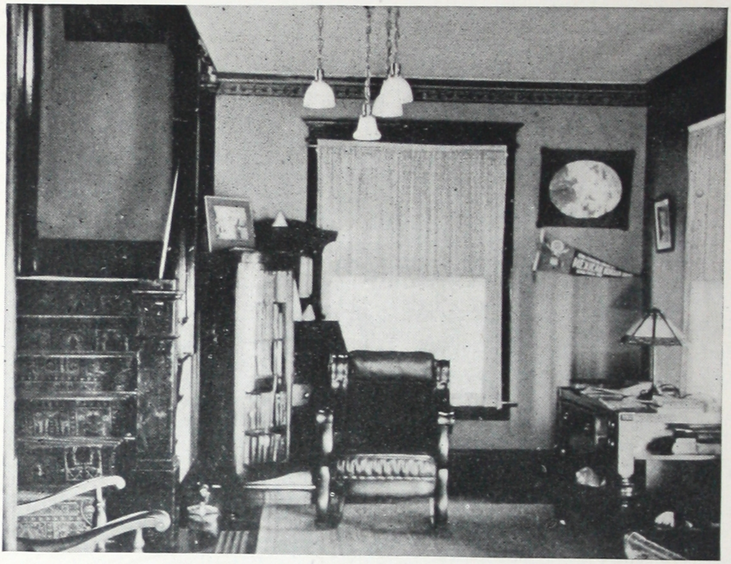

Fig. 5—Fixtures Well Suited to the Room. The Table Lamp Contains Two 20-Watt Lamps, While Four 20-Watt Lamps Are Used in the Ceiling Fixture
The Plant Was Installed in 1911

The selection of fixtures and reflecting glassware is dependent in part upon the location of the lighting outlets and the character of the furnishings of the room. Lamp fixtures and reflectors should be in harmony with the general appearance of the room and need not be expensive. Fig. 5 shows good judgment in the selection of inexpensive lighting fixtures—the fixtures harmonize completely with the other details of the room. Sometimes fixtures are selected which, although of pleasing design, do not fit in with the decorative scheme of the room. Simplicity in fixtures and glassware exhibits good taste in lighting for the average home. Violation of good taste in the supporting fixtures, as far as the non-luminous parts are concerned, does not usually affect the lighting itself, but does lower the esthetic value of the whole room. However, care should be exercised to see that heavy fixture decorations are not placed in the path of light from the unit.

With the variety of designs available in lighting equipment, it is easy to secure effective harmonious combinations with the room decorations as well as to have good illumination. In order to further

the scheme of decoration, colored reflectors are frequently useo. Discrimination should be exercised, however, in selecting these reflectors because sometimes they are completely altered in appearance when they are lighted from within. Good reflecting equipment, from the illumination standpoint, is absolutely essential for without it discomfort and eye strain are sure to follow. A thinly frosted glass or light-density opal reflector or globe does not diffuse or reflect the light rays properly, but there are numerous designs of opal and special prism glass which correctly diffuse and reflect the light rays.

No matter how good a lighting installation is, it can become very inefficient in a short time if it is not suitably cared for. A scarcely noticeable deposit of dust on the reflecting or transmitting surfaces may cause as high as a 30 or even 50 per cent loss of light. It is not infrequently the case that a lighting system which has proved entirely satisfactory when first installed has, after several months, appeared inadequate due solely to lack of regular and frequent cleaning.

The Lighting of Outbuildings

Outbuildings usually do not require a high intensity of illumination and in nearly all cases 20-watt lamps properly spaced will furnish sufficient light.

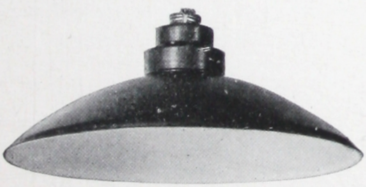

Fig. 6—Typical Enameled Steel Dome Reflector

The horse barn and the cattle barn generally have feeding alleys and cleaning alleys. For the feeding alley 20-watt lamps placed about 20 feet apart along the length of the alley will give sufficient illumination. If the ceiling is high enough to permit the use of reflectors, enameled steel dome reflectors, of the general type shown in Fig. 6, may be installed. The cleaning alleys require more light because here the animals are cleaned and the horses harnessed, and a 20-watt lamp should be placed at the back of each stall. If there are ten or more stalls, it is advisable to put the lamps for the first five stalls on one circuit, the second five lamps on a second circuit controlled by a separate switch, and so on. This will avoid the necessity of burning all the lights in the cleaning alley when the light from only a few is being used. Wire guards

placed around the bare lamps will minimize breakage, but the guard should not be constructed of wire so heavy that much of the light from the lamp will be absorbed.

One 20-watt lamp in an enameled steel dome reflector located near each hay chute, and hung high, will usually give enough light for the hay loft in the barn.

In the hog house with the usual arrangement of individual pens and with the feeding alley along the middle of the building, 20-watt lamps in enameled steel dome reflectors spaced 15 to 20 feet apart over the feeding alley will give sufficient light.

Two 10-watt lamps will light the garage satisfactorily. An extra socket for a "trouble-lamp" should be placed on the wall handiest to the engine of the automobile. A 20-watt or even a 40-watt lamp in a wire guard will be found convenient for this work.

Fig. 7—Straight-Side Bulb, 20-Watt MAZDA B Country Home Lighting Lamp.

The silo gives a special problem in that the working surface is constantly being lowered until the silo is empty. A solution is found in the use of a 100-watt MAZDA C lamp in a concentrating prismatic-glass reflector suspended from the center of the roof. The switch may be placed at the foot of the ladder leading up into the silo. While the silo is being filled, the reflector and lamp will probably become covered with dust and should be cleaned while yet easily accessible. The wires can usually be most conveniently run up the chute but if they are led up through the inside of the silo, they must be run in moisture-proof iron pipe.

The suggestions given in the preceding paragraphs may, of course, be applied in the lighting of outbuildings other than those specifically mentioned. The principal points which must be given consideration are convenience in the location of switches, a serviceable placement of light sources, and the use of good reflectors where reflectors can be used to advantage.

Fig. 8—Pear-Shaped Bulb, 50-Watt MAZDA C Country Home Lighting Lamp.

Lamps

Lamps for country home lighting service are rated as 16-cell lead battery or 24-cell nickel-steel battery (28-32 volts). This means

that the lamps will operate satisfactorily through this range of voltage. The pressure is highest when the battery is being charged and falls to the lower value as discharge proceeds.

There is a variety of MAZDA lamps for use with country home lighting outfits as the accompanying table shows. All MAZDA B lamps regularly manufactured for this service are made in the straight-side bulb which is illustrated in Fig. 7; the MAZDA C lamps use the pear-shape style shown in Fig. 8.

Care should be taken to see that the reflector is of a size adapted to the lamp with which it is to be used. If it is necessary to use lamps too large for the reflectors which may be at hand, it will generally pay to purchase new reflectors. When the filament is exposed to view even though the reflector is of the correct size for the lamp, a bowl-frosted lamp, that is one having the lower half of the lamp bulb frosted, should be used, particularly in the house. Such a case would exist in a direct-lighting reflector suspended from the ceiling. All the lamps listed in Table 1 may be secured bowl-frosted, full-frosted, or clear.

The lamps are equipped with medium-screw bases which are universally used for household lamps and which will fit any standard socket for lamps of this general class.

Table No. 1

Technical Data on MAZDA Lamps for Use With Country Home Lighting Outfits

These lamps are generally used on the circuits of country home lighting outfits having 16 cells of lead storage battery or 24 cells of nickel-steel storage battery in connection with a generator lighting system.

Labeled Watts (Nominal)	Lumens per Watt	Watts per Spherical C.-P.	Type and Size Bulb	Diameter Bulb, Inches	Maximum Over-all Length, Inches	Base Regularly Supplied	Standard Package Quantity
(28-32 Volts) MAZDA B Lamps							
5	8.73	1.44	S-14	1¼	4	Med. Screw	100
10	9.17	1.37	S-17	2⅛	4⅝	Med. Screw	100
20	9.74	1.29	S-17	2⅛	4⅝	Med. Screw	100
40	10.13	1.24	S-19	2⅜	5¼	Med. Screw	100
(28-32 Volts) MAZDA C Lamps							
50	13.96	0.90	PS-20	2½	5½	Med. Screw	50
75	14.78	0.85	PS-22	2¾	6⅛	Med. Screw	50
100	15.71	0.80	PS-25	3⅛	7⅛	Med. Screw	24

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MAY 31, 1918

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25	Street Series Alternating-Current Incandescent Lamp Circuits.
26	The MAZDA Lamp in Photography.
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28	Show-Window Lighting.
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30	Protective Lighting for Industrial Plants.
31	Reducing Operating Costs by Adapting 220-250 Volt Circuits to MAZDA Lamps of the 110-125 Volt Class.
32	Light Projection: Its Application.
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